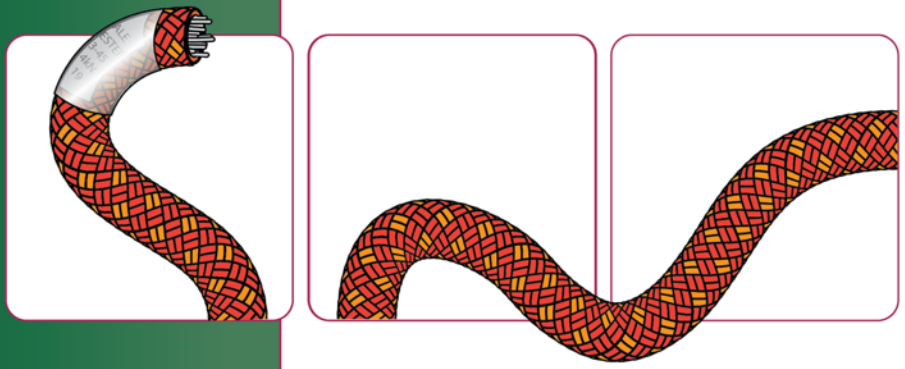
Arboriculture Australia™

NZARB™
New Zealand Arboricultural Association Inc.



ARBORIST ROPES

SELECTING, INSPECTING AND USING ROPES FOR TREE CLIMBING AND RIGGING

MIS302

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

First Published in Australia in 2018 by Arboriculture Australia Ltd.

Address: PO Box 80, Marleston
SA 5033, Australia
Telephone: 1300 664 374
International: +61 8 8293 1522
Email: enquiries@arboriculture.org.au
Website: www.trees.org.au

Arboriculture Australia™ is a not-for-profit institution and is the peak national organisation promoting and representing tree workers, arborists, professional tree management, utility vegetation management and urban forestry throughout Australia and the Asia Pacific region.

Arboriculture Australia™ is proud to be the publisher of the Minimum Industry Standards series. Printed in Australia.

© Arboriculture Australia Ltd 2018 The copyright includes all text, drawings, sketches and images, except where otherwise marked.

All rights reserved. This book is subject to copyright. Except under the conditions described in the Australian Copyright Act 1968 and subsequent amendments, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, duplicating or otherwise, without the prior permission of the copyright holder.

The information in this document has been reviewed and validated by state, national and international industry representatives and deemed to be an accurate description of appropriate applied-practice skills and techniques, however neither Arboriculture Australia Ltd or the New Zealand Arboricultural Organisation accept any responsibility or liability for the accuracy of any information contained in this document or the consequences of any person relying on such information. All arboriculture work undertaken or advice given is at your own risk.

All enquiries should be addressed to the publisher.

ISBN 978-0-6486866-6-8

Written and illustrated: Joseph Harris
Into Trees

Editor: Kerry Jennings
Aerial Consultancy

Design and Layout: Joseph Harris
Into Trees

Document code: MIS302
Document title: Arborist Ropes
Revision date: September 2020
Version 2nd Edition

Ratified and distributed in New Zealand by the New Zealand Arboricultural Association.

Address: 23 Alma St, Nelson,
7010, New Zealand
International: +64 4 472 6330
Email: admin@nzarb.org.nz
Website: www.nzarb.org.nz

Acknowledgements

Arboriculture Australia™ and NZArb™ would like to thank the following volunteer technical experts, industry representatives and reviewers who spent countless hours contributing information to this document, reviewing draft versions or working to move this project forward.

Arboriculture Australia™ and NZArb™ gratefully acknowledge their contribution, personal time, their invaluable expertise and their ongoing support to bring this project to fruition:

Barton Allen-Hall
James Bade
Guy Badger
Maja Blasch
Michael Byrne
Jessie Carson
Grant Cody
Will Dunn
Craig Hallam
Daniel Heyburn
Sam Hardingham
Paul Java
Richard Kenyon
Kiah Martin
Jeremy Millar
William Mittins
Anthony McConchie
Brett Moir
Michael Palamountain
Paul Poynter
Michael Ramsden
Mark Roberts
Andreas “Rossy” Ross
Adam Tom
Richard Tregoweth
Dave Vizer
Alex Witt

Much of the original text and information was compiled by Scott Sharpe and Frank Somerville in 2008. The original document was revised by Joe Harris and released by the Victorian Tree Industry Organisation in 2010.

The Arboriculture Australia™ Minimum Industry Standard series is dedicated to all our fellow workers who have lost their lives or have been permanently injured working in the arboriculture and vegetation management industries across Australia.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

A Minimum Industry Standard for rope use in arboriculture

This book is one in a series of Minimum Industry Standards produced by Arboriculture Australia Ltd and the New Zealand Arboricultural Association in consultation with the national arboriculture community in both countries. These industry peer-reviewed documents provide a 'body of knowledge' which is shared by practitioners and can be used as the basis for training, dissemination of skills and professional development. MIS302 covers the fundamentals of rope selection, qualities of ropes and rope use: it is intended to provide a solid foundation of rope knowledge on which practitioners can build.

Users are recommended to consult MIS301 Arborist Knots for more details about knot selection and knot tying. Details of the use of ropes for climbing and rigging operations are contained within the relevant MISs for those work tasks.

Industry partners

The Minimum Industry Standard series was produced by Arboriculture Australia Ltd and the New Zealand Arboricultural Association in partnership with the following state and national industry bodies.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Table of Contents

A Minimum Industry Standard for rope use in arboriculture i

Industry partners i

Ropes for arboriculture 1

Rope terminology: parts of a rope 4

Rope selection 7

1: Select the right rope for the job in the first place 7
Properties of ropes and rope terminology 7
Rope standards 19
Rope materials 20
Rope construction types 24
Common arboricultural rope constructions 25

Rope inspection 28

2: Inspect rope before each use 28
3: Conduct regular documented third-party rope inspections 28
Rope inspection form excerpt 30
Rope inspection checklist 31
Splices in rope 33
Inspecting splices 33

Rope use 36

4: Use rope correctly and observe WLLs 36

Rope storage and transportation 38

5: Clean, store and transport rope carefully and correctly 38

Appendix A: Rope inspection checklist 39

Glossary 40

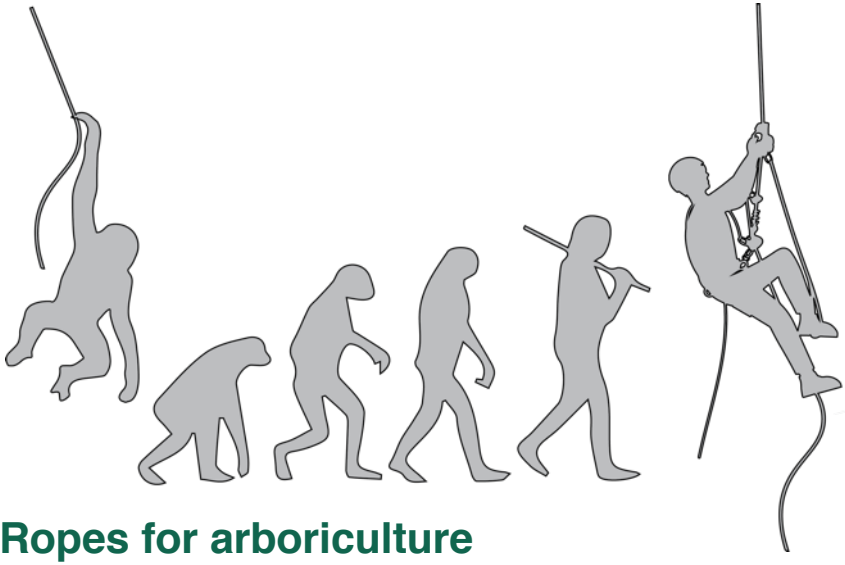
References 49

Minimum Industry Standards 50

Using the MISs in training and assessment 52
Disclaimer for MISs and all associated documents 54
Industry stewardship program 55

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023



Ropes for arboriculture

Humans have used rope in one form or another since the earliest days. The use of creepers or vines as climbing aids arguably pre-dates any other form of tool, taking us back to a time before the species learned to walk upright or make fire.

In the arboricultural industry ropes are used primarily for safety and rigging. To use the correct rope for the correct task, arborists should know the different types of rope and how to correctly use and care for the ropes available.

Knowing the types of ropes available allows you to select the best rope for the job. Important considerations are:

- strength (minimum breaking strength)
- elasticity (elongation)
- weight
- abrasion resistance
- inspection and maintenance requirements.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Definition of rope

A rope is a length of fibres, twisted or braided together to improve strength for pulling and connecting.

It has tensile strength but is too flexible to provide compressive strength (i.e. it can be used for pulling, not pushing).

Rope is thicker and stronger than similarly constructed cord, line, string or twine.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Knowing your rope

Rope manufacturer and type: try to find their rope data sheet, which will give you more information about the rope construction, inspection and materials

Rope construction: this describes the way in which the rope is made; different rope constructions behave differently and require different inspection

Rope materials: different materials have very different properties, such as elasticity, heat resistance, abrasion resistance or strength

Rope specifications: rope diameter, minimum breaking strain, working load limit, elasticity, recommended service life, splice type, care and inspection regime

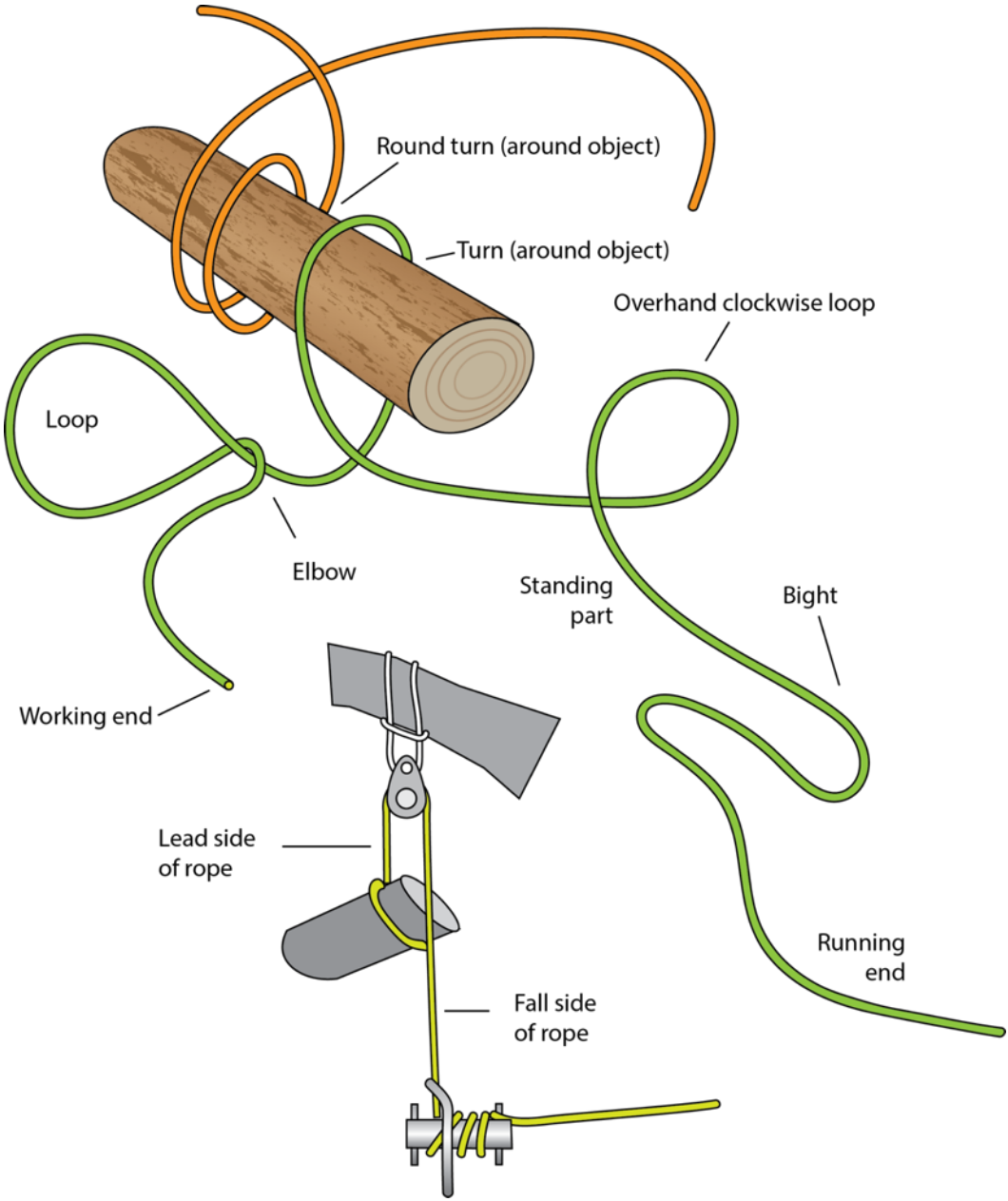
Rope qualities: rope qualities are the result of the previous properties; qualities include flexibility, knotability, grip, profile, UV resistance and others

Intended use: ropes must be suitable for their intended purpose; select ropes that will perform well for their intended use

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope terminology: parts of a rope



© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Use correct arboricultural terminology to refer to the respective parts and configurations of rope. Once you have familiarised yourself with these terms you will be able to easily identify and communicate which part of a rope is being used at a particular stage of knot tying or attaching the rope to a device.

The **working end** is the end that you are using to tie a knot; the **running end** is the end you are not tying. You may still be using the running end in climbing/rigging situations.

The rope in between the two ends is the **standing part**.

There are other various **loops** and **turns** that are made in the rope to help form knots either called a **bight**, a **loop**, an **elbow** or an **uncrossed loop**.

A **turn** is where the rope loops around an object.

See picture on previous page for these terms and parts.

Because there may be more than one rope being used at any one time, arborists refer to each rope as a **line** (a rope becomes a line once it has a been given a purpose). In other words, the rope that you climb with is called a **climbing line**. The rope that you use to pull something over with is called a **pulling line**.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

SERVICE LIFE OF A ROPE

ROPE SELECTION, CARE AND USE

SELECTION CRITERIA FOR ROPE:
- Strength, weight, diameter, durability, elasticity, hand (flexibility), profile, materials, heat resistance, UV resistance, grip attributes, behaviour under load
- Construction type and materials
- Splice type (if any)
- Manufacturer recommended service life - select ropes from reputable manufacturers wherever possible

CORRECT USE OF ROPE:
- Keep loads within the manufacturer recommended Working Load Limit - remember to reduce WLL if the rope is bent or knotted. Some high-tech fibres can lose 90% of their strength when knotted.
- Monitor rope use for dynamic / shock loading - for low-elasticity ropes WLL can be exceeded by dropping even small loads
- Use rope with correct hardware diameters and connections. Tight bend ratios will massively reduce WLL and reduce cycles to failure
- Monitor rope for heat buildup and possible internal heat damage. Heat damage can be caused by rapid movement across a device under load, followed by an extended period without movement in contact with the device

CORRECT CLEANING AND STORAGE OF ROPE:
- Buildup of dirt and debris will abrade rope
- Some ropes can be 'rotted' by extended periods of damp
- Ensure that ropes are cleaned properly before being stored
- Store and transport ropes carefully, avoiding any possibility of abrasion, or contact with fuels, oils, or other chemical contaminants
- Prepare rope correctly for storage - some ropes should be coiled, and some should be flaked into storage bags, depending on construction

INSPECT:
- Full length of rope for damage, including cut strands, damaged strands, inconsistent diameter, volume reduction, glazing or melting, discolouration, flat areas, lumps, bumps or stiffness
- Use rope construction and inspection information recorded above to give failure conditions for each rope

BEGIN HERE:
Select correct rope for purpose

1. **Carefully select rope that will perform well during intended use**
2. **Inspect rope carefully before each use**
3. **Use rope correctly, within recommended working load limit**
4. **Clean and store correctly after each use**
5. **Conduct regular documented third-party inspections**

PASS

FAIL

ROPE INSPECTION & RECORDS

RECORD:
- Manufacturer
- Rope type
- Rope diameter, MBS, WLL, rope length, materials, construction, splice type (if any), any specific care or inspection requirements
- Manufacturer recommended service life - record date of retirement in equipment record form

WHERE ROPE FAILS INSPECTION:
- Where rope fail inspection, either cut out damaged/failed area, or cut and retire rope.
- Record retirement and reasons.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope selection

1: Select the right rope for the job in the first place

Properties of ropes and rope terminology

Abrasion resistance

Some rope materials and constructions are inherently more abrasion resistant than others. For example, twisted 3-strand polypropylene cordage can be used for natural crotch rigging on rough barked trees. Whilst the rope will be damaged by this use, the damage will be easy to inspect and the rope is still likely to offer a good service life. A soft, hollow-braid high-tech fibre rope used in the same manner might be permanently damaged from one operation.

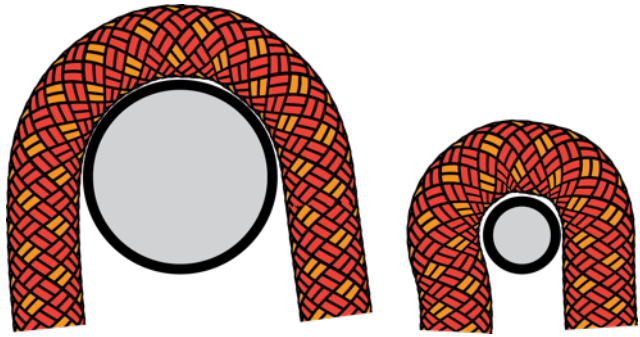
Where natural crotch climbing or rigging will be used, or where the rope is likely to be used in rough or dirty environments, wherever possible select materials and construction that provide high abrasion-resistance.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Bend ratio or **Bend radius**

When a rope is bent over a point, the outer part of the rope must cover more distance than the inner part, so it is 'stretched' and carries a greater share of the load. As can be seen in the image below, the tighter the radius of the bend the more disparity there will be in the two parts of the rope, and the more that the rope will be weakened as a result. This is described as bend ratio – the ratio between the diameter of the sheave or post that the rope is bent over and the diameter of the rope.



Remember: tighter bend ratio = weaker rope

Most manufacturers recommend a minimum bend ratio of 10:1 for twisted ropes and 8:1 for braided rope but ratios of 4:1 are widely accepted within the arboriculture industry.

The image above on the left is an acceptable bend ratio before rope strength will be significantly reduced. If you are selecting ropes to use in configured climbing or rigging systems, recognise that the hardware in the system will impose limits on the rope diameters you can choose.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

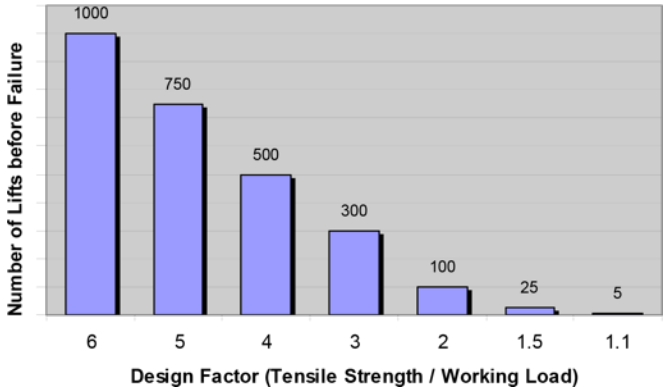
Cycles to failure

Cycles to failure is defined by the International Society of Arboriculture as the *number of times a rope or other piece of equipment can be used with a given load before mechanical failure*.

Applying greater loads to rigging components will reduce the number of operations in which those components can be used before failing.

The chart below shows the number of cycles before failure recorded in a test by Samson cordage.

Please note that this test was in laboratory conditions on clean rope, not on a tree work site with knots, tight pulleys, dynamic loads and abrasive bark.



Source: *Evaluation of current practices in rigging and dismantling*, Health and Safety Executive, UK 2008

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Design factor
or
Safety factor

The design factor or safety factor is the ratio of minimum breaking strength (MBS) to working load limit (WLL). In other words:

WLL x safety factor = MBS

The relationship between these three parameters means that, provided any two of them are given, the third can be calculated.

Some manufacturers will provide just MBS or WLL; in these cases an assumed safety factor of 10:1 for climbing ropes and 5:1 for rigging ropes can be used to estimate the other value.

In other cases, the manufacturer will specify the safety factor or design factor they recommend. Always check that you are using the equipment as specified.

Working well within the WLL will allow for confident rigging and climbing operations, and will allow rope to be used for the full manufacturer's recommended service life.

Working above the WLL will damage the rope and reduce the **cycles to failure**.

Dynamic rope

Dynamic rope is climbing rope that is designed to have high **elongation** in a fall, which acts to absorb the energy of the fall.

Commonly used in rock climbing, where climbers pass their anchor points and may have significant falls, it is almost never used in arboriculture.

Most arboricultural ropes have between 0.5% (ultra-static) and approximately 5% (semi-static) elastic elongation at 30% of MBS.

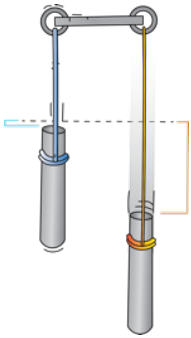
© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Elasticity or

Elongation or

Elastic elongation



Elasticity or elastic elongation describes the proportion of its length that a rope will stretch under a given load or at the point of failure.

More elastic ropes will stretch more, helping to prevent shock loads – this could be critical if a climber were to take a fall or when conducting rigging operations. In the image on the left, the blue rope has brought a dropped weight suddenly to a stop, generating a high shock load. The orange rope, with more elasticity, has stopped the load more gently.

Elastic ropes can also make climbing and rigging operations more challenging however, making it harder for climbers to work position or requiring significantly more pre-tension when rigging.

Experienced workers will use a range of ropes, often selecting low-stretch ropes for operations such as guying or lifting, and higher-stretch ropes for operations such as negative rigging. In some circumstances, such as when using guy ropes to control the felling of a heavily side-leaning tree, it can be critical for arborists to know and apply the exact extension of their ropes under specific loads – make sure that you know this information for the ropes that you are using!

Ropes are often categorised as either ‘static’, meaning that they have very little stretch or ‘dynamic’ meaning that they have more stretch. These terms are, however, relative since all ropes have some stretch. Some of these terms have their origins in mountain climbing where the higher stretch versions are used to absorb energy if the climber falls. See: **dynamic rope**.

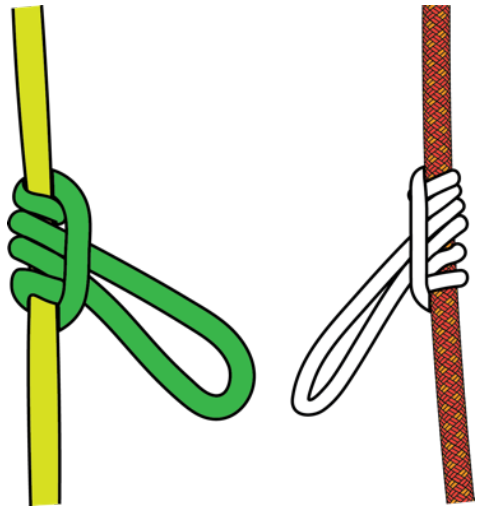
© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Grip

Rope grip describes the degree to which a rope or prusik loop will run or bind when used in a rope-on-rope configuration in conjunction with other cordage. Grip is a function of rope profile, firmness, materials and coating, and should be assessed when configured with the other ropes or devices with which it will be used.

When using rope-on-rope friction during climbing and rigging, for example when using a prusik hitch or similar to manage friction in a system, always test the configured system and do not assume that the same knot will work with every combination of cordages! In the image below, a 4-wrap English prusik will work perfectly on soft, flexible rope with high grip. When using thin, firm, smooth-profiled rope or stiff hitch cord, additional wraps may be required.



© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Hand or **Flexibility**

A rope's hand or flexibility describes how 'bendy' a rope is and how easy it is to tie knots with that rope.

Stiff, rigid ropes may make it difficult to tie knots and users may find that knots tied with these types of rope tend to open when unloaded.

However, stiffness may sometimes be a positive quality in a rope, particularly for climbers using modern climbing devices such as the ART SpiderJack or Petzl ZigZag.

Heat resistance

Different rope materials will have different resistance to heat. At the low end, **polypropylene begins to weaken and melt at 65 °C**, which is not a difficult temperature to reach when conducting rigging operations, even on a cold day.

The temperatures at which rope materials can be weakened by as much as 50% are:

- polypropylene at 100 °C (begins to degrade at 65°C)
- nylon at 175 °C
- polyester at 175 °C.
- Dyneema at 100 °C

Take care when selecting ropes that have a low-heat-resistant core protected by a non-load-bearing cover, such as many specialist access lines. It can be possible to heat-damage the core – which carries all of the load – without noticing any damage to the cover.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Knotted strength

Knowing about the reduction in strength caused by knots, hitches or other bends in a rope or sling is important for assessing configured strength and working within accurate WLLs.

Different rope materials and constructions can suffer different reductions in strength when knotted. In some tests, **knotted high-tech fibres such as ultra-high-molecular-weight polyethylene have lost 90% of their original strength**.

In addition, different knots will weaken the same rope by a different amount. Information relating to this is in MIS301 Arborist Knots.

If you don't know, you can usually estimate the likely reduction in strength of a knot by inspecting the bend ratio that the knot makes under load. The more open the bend, the less the knot will weaken the rope. This is why the **round-turn and two half-hitches** knot is so strong – the rope makes an additional 360° turn around the structure before any tightly-twisted knots are applied.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Minimum breaking strength

MBS, also known as minimum breaking strain , is usually expressed in Kilonewtons (kN), and is the minimum load above which an item of lifting equipment can be expected to fail **when new** and **when used in the correct configuration**.

This number will rapidly drop i.e. the equipment will break much sooner than expected, when using old, worn, damaged or mis-configured equipment. In some tests, ropes broke below the MBS on the first 'on site' use; in other words, as soon as they have been coiled for sale by the manufacturer they may have lost 10% of their strength!

All else being equal, select ropes with the highest available MBS. A load of 200 kg represents 2% of the strength of a rope with an MBS of 10,000 kg. The same load represents 4% of the strength of a rope with an MBS of 5,000 kg. The weaker rope works harder and so will be retired sooner.

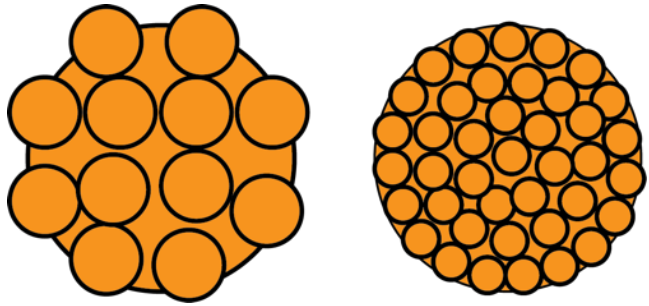
Conversely, a rope with a higher MBS may be a worse choice if other qualities are not suitable for the intended use. For example, if a high-MBS rope with low elasticity is used for negative rigging, the high shock loads will cause more strain on the rope than a lower-MBS, more elastic alternative.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Profile

A rope's profile describes the smoothness or roughness of circumference of an imaginary cross-section of the rope, and is normally a function of the rope's construction. Braided ropes with a high strand count (for example, 48- or 72- strand double braids, or 24- strand twin-carrier double braids) will usually be smoother or more regular in profile, whereas twisted ropes or ropes with a low strand count will be less regular.



This profile – coupled with the rope materials and any coating that has been applied – will determine the way that the rope behaves when used with other components of the system.

Climbers should select ropes that function well with their chosen climbing systems. For example, climbers using mechanical friction devices will normally find better performance by selecting ropes with as smooth a profile as possible: ropes with a low strand count will have a 'rougher' profile and will not tend as easily through the device.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Recommended rope diameters

For some hardware such as blocks, pulleys and bollards, the manufacturer may provide a recommended range of rope diameters. This may be printed on the device (sometimes shown as ⌀) or found in the manual.

Exceeding the recommended rope diameter may result in abrasion of hardware, damage to rope, or reduction in rope strength (see bend ratio).

Spliced strength

Splices can be a good way of retaining rope strength in configured systems but will still normally reduce the strength of a rope. For some ropes it is recommended that only splices be used to attach the rope to any hardware or objects.

For the purposes of this MIS, it will be assumed that cordage has been spliced by the manufacturer rather than the end user and that the spliced strength is available from the rope label or manual.

Ultraviolet resistance or **Ultraviolet stability**

Working on Australian and New Zealand tree sites can expose arborists and their equipment to high levels of ultraviolet (UV) light… and both must be protected!

UV degradation can be extremely rapid for some materials, such as plastics or polypropylene.

Remember to store and transport any ropes correctly and avoid storing ropes in direct sunlight.

Weight

The weight of rope refers to how heavy the rope is per metre of length. Lighter ropes will be easier to transport and easier for workers to install and use.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Working load limit

The recommended WLL of a piece of equipment is the maximum recommended load it should experience when correctly configured during regular operations. This amount will be considerably lower than the MBS.

Either MBS or WLL will usually be printed on the device or available from the product guide or manual. Either one can be calculated from the other by multiplying or dividing by the **design factor** or **safety factor**.

WLL x safety factor = MBS.

Working Load Limit is sometimes described as Safe Working Load or SWL.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope standards

Select ropes that have been certified as compliant with the requirements of the appropriate standard listed below.

Component	AS/NZS (Australian/ NZ Standard)	EN (European Standard)	ANSI (American Standard)
Accessory cord	AS 4142.3	EN564	
Rope – dynamic Note: dynamic ropes (EN1892) are not commonly used in arboriculture	AS 4142.3	EN892	
Rope – low stretch	AS 4142.3	EN1891	C11801–08
Sling and loop		EN354 EN566 EN795	

Standards describe a particular collection of tests that a product has been shown to meet or exceed. For rope, they usually include the ability to sustain specific static and dynamic loads, sustain a certain amount of UV, heat or abrasion damage, or to function in particular conditions.

In some cases (such as harnesses), the tests required to meet Australian and New Zealand Standards are more stringent than those used overseas. In most cases however, standards are similar or close to analogous. Tree workers should select ropes and equipment that meet appropriate Australian and New Zealand or international standards and are suitable for their intended function.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope materials

Natural fibres

Natural fibre ropes such as manila, sisal, coir, hemp or flax are not used in modern arboriculture and should be avoided. They tend to exhibit inconsistent MBSs and WLLs, and tend to deteriorate too quickly to be trusted for prolonged use.

Synthetic fibres

Nylon is the strongest rope material in common use in arboriculture (excluding high-tech fibres). When stretched it has a 'memory' for returning to its original length. For this reason it is excellent for absorbing shock loads. Nylon absorbs water and will lose strength by approximately 10-15% when wet and will shrink the rope. Nylon is also severely damaged by acids. Nylon lasts 4–5 times longer than natural fibres because it has good abrasion resistance and is not damaged by oil or most chemicals. Like manila, nylon has good resistance to UV deterioration from sunlight. It can have around 30% extension at break and a melting point between 220°C - 265°C.

In arboriculture, nylon ropes are generally used for specialist rigging jobs to try to reduce the impact of shock loading. For most day-to-day tree work nylon ropes tend to be a little too stretchy, however this is also dependent on the rope's construction.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Polyester is very close to nylon in strength when a steady force is applied. However, polyester stretches less than nylon and does not absorb shock loads as well. It is not affected by moisture and is resistant to most acids; it can be affected by petroleum products like nylon, but it is superior in resistance to abrasion and sunlight.

Polyester represents by far the largest percentage of ropes used in arboriculture because it has the right durability, elongation and strength requirements for day-to-day industry requirements.

Polypropylene is cheap and light-weight. Poly is affected by sunlight deterioration more than any other synthetic or natural fibre rope but its life can be extended by storing it away from direct sunlight. Poly begins to weaken and melt at 65 °C, the lowest melting point of all synthetic ropes (excluding high-tech fibres). It is not as strong as nylon or polyester and has similar (38%) elastic elongation at break to polyester. Because poly is less expensive than other fibres it is the most popular all-purpose rope for the average consumer.

In arboriculture, poly ropes are generally used for rough rigging work where if the ropes are damaged it is of little concern.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

High-tech fibres

In recent years, developments with synthetic fibre brands such as Kevlar, Spectra/Dyneema, Technora, Vectran and others have led to the production of high-performance–high-tech ropes. These synthetic fibres are used by leading rope manufacturers for the possible replacement of conventional steel wire rope because of the weight to strength ratio. High-performance ropes are used in a range of applications – marine, oilfield, offshore, shipping, mooring, construction, aerospace – and arboricultural climbing and rigging operations.

It is important to note that while these high-tech fibres often have incredible strength for their diameters, some have extremely poor abrasion or heat resistance – some have such poor abrasion resistance that they can actually self-abrade if poorly spliced.

In addition, tests have shown that knotting these fibres can dramatically reduce their strength. In some tests, **knotted high-tech fibres have lost 90% of their original strength**.

Aramids such as **Kevlar** and **Technora** are low stretch, high strength fibres with good resistance to creep and high temperatures. Their UV and abrasion resistance are poor, which means that an aramid rope is best jacketed in another material such as polyester. Aramids have a poor resistance to knots and bending requiring large sheaves on pulleys.

High Modulus Polyethylenes (HMPE) such as **Dyneema** and **Spectra** are low stretch high strength fibres, however HMPE ropes are lighter than aramids (relative density of HMPE 0.97) and do not suffer from the same degree of strength loss when used around small bend ratios. HMPE cordage has high abrasion resistance, very low elongation, the highest strength to weight ratios of any fibre and approximately twice the strength of steel wire of the same diameter. HMPE has excellent flex fatigue resistance but a low resistance to heat. HMPE is excellent for winch lines due to its low elongation. Low elongation results in a poor ability to handle shock loading.

© Arboriculture Australia Ltd 2018

Arborist ropes – characteristics of common fibres						
Fibre name	**Nylon**	**Polyester**	**Polypropylene**	**Technora**	**Dyneema**	**Vectran**
Used in	Yale *Polydyne*, Samson *Blue Streak*	Yale XTC, Samson *Stable Braid*	New England Safety Blue *Hi-Vee*	Samson *Ice Tail*, Donaghy *Armor-Prus*	Samson *Amsteel*, New England *Dynaglide*	Yale *Bee Line*
Melting point	220-250 °C	250 °C	110 °C	500 °C	130 °C	330 °C
Comment	Inspect ropes carefully if heat damage is suspected		Begins to degrade at 65 °C	Does not melt Chars at 500°C	Use only where heat build-up can be managed	Degrades at 250 °C
Strength	High	High	High	Very High	Very High	Very High
Abrasion resistance	Very Good	Very Good	Good	Very Good	Very Good	Very Very Good
Ultimate elongation (extension at break)	20-30%	12-15%	38%	4–5%	2–3%	3%
UV stability	Low	Good	Very Poor	Poor	Good	Very Good
Water absorption	High	Low	Low	Low	Very Low	Low
Acid	Susceptible	Resistant	Resistant	Susceptible	Susceptible	Resistant
Chemical and Solvents	Resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Notes	Excellent energy absorption where height is available, e.g. rope stretches to absorb energy. Loses 15% strength when wet.	Most commonly used fibre in Arboriculture industry. Excellent all-round fibre.	Take care with UV exposure and heat damage	Used in most heat resistant friction cords.	Very low co-efficient of friction but will melt if run across surface which accumulates heat. Floats on water.	Not commonly used except in Bee Line. Excellent rigging line where high strength and low stretch needed. Very expensive.
Uses	Composite rigging and climbing lines.	Climbing and rigging lines. Friction Cords.	Composite climbing and rigging lines.	Friction cord.	Rigging slings and winch lines.	Composite rigging ropes.

Table originally compiled by Adam Tom 2013

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope construction types

There are two broad types of rope each of which has very different characteristics: twisted rope and braided rope. In order to optimise a rope's performance and safety it is important to select the correct rope construction for a given application.

Twisted ropes are made by twisting bundles of individual yarns together to form three strands, which are then themselves twisted together to form the rope. As the successive bundles of fibre are twisted together, the direction of the twisting is alternated so that the torque resulting from twisting in one direction is balanced against the torque resulting from twisting in the other direction. This counteracts the tendency of the three strands to unwind. These ropes can be recognised by their spiral shape. Some larger ropes may be made up of more than three strands.

Twisted ropes are typically less expensive than braided ropes because the manufacturing process is faster. Twisted ropes can be easily spliced, however, despite the balancing of torque achieved by alternating the direction of the twist, these ropes retain some torque and therefore have a tendency to kink up, and to rotate under load.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Braided ropes come in various braiding patterns but always consist of bundles of fibre formed into ‘strands’ and then interlaced by passing each strand over and under other strands. This structure creates a round rope as opposed to the spiral shape of twisted ropes. This round shape makes braided ropes well suited for use with hardware such as pulleys, winches and rope grabs. Generally speaking, braided ropes are inherently torque-free and non-rotating. Braiding is a relatively slow process, so ropes made in this fashion tend to be more costly than twisted ropes.

When braiding ropes, there are a number of variables the manufacturer can use to alter characteristics such as strength, elongation, flexibility and durability. A brief description of some of the more common types of braided ropes follows.

Common arboricultural rope constructions

Solid or sash braid ropes are formed by braiding strands of fibre in a reasonably complicated pattern, with or without a filler core in the centre of the rope. Solid braid ropes tend to maintain their round shape and therefore work exceptionally well in pulleys and sheaves. They tend to have high elongation but are generally less strong than other braided constructions.

Diamond braid ropes are used extensively in arboriculture as climbing lines and cheaper rigging lines. They are formed by rotating half the strands of fibre in one direction, while the other half rotate in the other direction crossing alternately over and under each other. Diamond braid ropes tend to be flatter than some of the other constructions. Often a filler is put in the core of the rope to make it rounder and firmer or to build it up to a desired size. Diamond braid ropes tend to have moderate strength.

Double braid ropes are used extensively in arboriculture as high-quality rigging lines and many modern light-weight climbing lines. They are made by braiding one rope over the top of another, so you actually have a rope within a rope. The inner rope and outer rope are generally

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

designed to share the load fairly evenly, though this depends on the particular cordage materials used. These ropes tend to be very flexible, strong and easy to handle. Eyes can be spliced into the ends of these ropes.

Some caution must be exercised where double braid ropes are run over pulleys, through hardware or in any situation where the outer rope may slide along on the inner rope and bunch up. This condition, often called 'milking', will result in a dramatic loss of strength by causing the entire load to go onto the inner rope, because the sheath is bunched up and therefore not under the same tension as the inner rope.

Kernmantle ropes are also used in arboriculture as climbing lines and specialist access lines. They are made by braiding a cover (mantle) over a core (kern). The core may be made of filaments of fibre lying essentially parallel inside the rope or it may be twisted into little bundles much like miniature twisted ropes. In some cases it will be made of small braided ropes.

Kernmantle ropes are always designed so that the inner core is taking most, if not all, of the load. The outer cover serves primarily to protect the fibres of the inner core. If 'milking' occurs on these ropes, it does not generally affect strength very much because the rope is designed so that the inner core is the load bearing member. These ropes are very strong and durable, and can be made to have very low elongation. Since the load bearing fibres are inside the protective outer cover, they are well protected from abrasion, dirt and ultraviolet rays. All other forms of rope have the load bearing fibres exposed, resulting in faster deterioration. One point of concern is that, with all of the load bearing capacity carried in cordage that is 'hidden' from inspection by the cover, kernmantle ropes can be hard to perform good inspection on.

Kernmantle ropes are often categorised as either ***static***, meaning they have very little stretch, or ***dynamic***, meaning they have more stretch. These terms are, however, relative since all ropes have some stretch.

Kernmantle ropes have their origins in mountain climbing where the higher stretch versions are used to absorb energy if the climber falls. The lower stretch versions are used in rappelling, rescue, and in most industrial safety applications where they are favoured because of their

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

inherent toughness and the efficiency with which rope grabs work on them. They tend to be more expensive than other ropes because they are normally made from very high-quality fibres and have stringent requirements for care in manufacturing, particularly where they are designed for use in life critical applications. Most of the higher initial cost is offset by their durability and because one can normally select a smaller kernmantle rope for any given application.

In arboriculture, ***dynamic*** ropes are almost never used. Most arboricultural ropes have between 0.5% (***ultra-static***) and approximately 5% (***semi-static***) elastic elongation under regular loads.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope inspection

2: Inspect rope before each use

3: Conduct regular documented third-party rope inspections

Selecting and inspecting ropes requires good knowledge of both rope qualities and intended rope usage. Nevertheless, proper inspection of all tree climbing equipment is an essential part of safe tree work. Unexpected rope failure may result in serious injury or damage, so all rigging and climbing equipment inspection should be conducted with the same thoroughness as the inspection of critical life support equipment.

Rope inspection should be conducted in two ways:

1. **Before each use, by the worker who will be using the equipment or a qualified supervisor.**
2. **By a competent third party, as part of a regular documented inspection regime**

Regular documented equipment inspection is a legal requirement for tree work.

Ensure that third party inspection is thorough, documented and regular.

Ensure that where equipment is identified as unsafe, or has reached the end of its service life, that it is immediately recorded as such and retired.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

What is the service life of my rope?

Most equipment will be produced with a manufacturer-recommended service life detailed in the product manual or in the rope data sheet on the manufacturer's website.

This recommended service life can vary significantly, even between two very similar ropes – always check the manual or contact the manufacturer. Ensure that you record when your rope was purchased and when it enters service – this will allow you to retire the equipment after an appropriate period.

Australia's harsh conditions and strong UV radiation can rapidly degrade some synthetic textiles. Always consider the recommended service life to be a maximum limit rather than a minimum! A lot of equipment will need to be retired long before its recommended service life has expired, particularly if it is exposed to sunlight or put away without being cleaned.

Who should I get to inspect my equipment?

Accessing qualified third-party equipment inspection may be challenging for some operators. Some standards explicitly define the qualification to be an equipment inspector as being different and higher to the qualifications of an operator. Operators may be trained in the *use* of equipment but may not be trained in techniques of research and methodical process that are required for documented inspection.

At a minimum, ensure that another trained and qualified worker conducts a thorough and documented check of all climbing equipment at least once every six months. If possible, try to find a qualified third party from outside of the business to conduct this inspection – they are less likely to be regular users of the equipment, and more likely to conduct a thorough inspection.

How should this be documented?

Ensure that you record when each piece of equipment enters service, each time it is inspected and when it is retired. Ensure that the person inspecting the equipment records the date of inspection, the name of the inspector and signs the documentation to verify that the inspection took place.

© Arboriculture Australia Ltd 2018

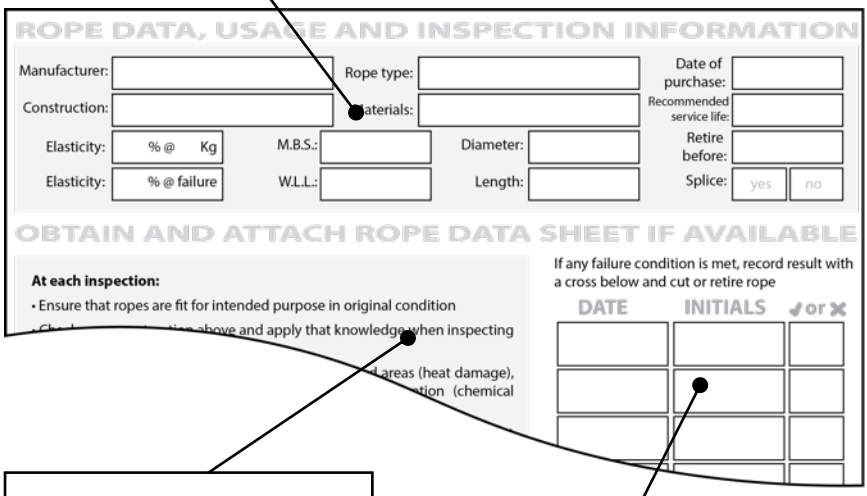
ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope inspection form excerpt

A full rope inspection form is provided at Appendix A.

This part of the form should be filled out when the rope is first purchased. It provides a space to record important service information for the rope, and should be made available to all workers who will be using the rope.

Please note that there is not a requirement to fill in every field. If the elasticity at failure is not know for example, it can be left blank.


ROPE DATA, USAGE AND INSPECTION INFORMATION

Manufacturer: | Rope type: | Date of purchase:

Construction: | Materials: | Recommended service life:

Elasticity: % @ Kg | M.B.S.: | Diameter: | Retire before:

Elasticity: % @ failure | W.L.L.: | Length: | Splice: yes no

OBTAIN AND ATTACH ROPE DATA SHEET IF AVAILABLE

At each inspection:

- Ensure that ropes are fit for intended purpose in original condition
- ...above and apply that knowledge when inspecting
- ...areas (heat damage), ...tion (chemical

If any failure condition is met, record result with a cross below and cut or retire rope

DATE	INITIALS	✓ or ✗

This part of the form describes the process that should be followed whenever conducting rope inspection, and gives the failure conditions at which point the rope should be retired.

This part of the form documents the regular inspections of the rope. It is an important record, which may be crucial evidence that the correct inspection procedure has been followed should there ever be an accident or health and safety investigation.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope inspection checklist

At each inspection

- ☐ Ensure that ropes were fit for the intended purpose in their original condition
- ☐ Confirm rope construction type and apply that knowledge when inspecting rope
- ☐ Carefully inspect full length of rope for damage such as glazed areas (heat damage), inconsistent rope diameter (internal damage), discolouration caused by chemical contamination, loss of rope bulk, cut strands or inconsistent texture
- ☐ Look particularly at areas where rope wear is likely to be concentrated such as at the splice and near the working end
- ☐ Check for cuts, puffs (pulled strands) and areas of excessive wear
- ☐ Ensure that all rope ends are secured and will not unravel. Consider melting, gluing, whipping or taping depending on rope materials and construction
- ☐ Inspect splices for correct selection and construction. Check whipping of splices – 'popped' whips are a sign that excessive loading has occurred and the splice has shifted
- ☐ Record results on rope inspection form

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Inspection failure conditions

Record failure and cut section or retire rope if any of the following are found:

- ☐ Original rope bulk reduced by abrasion:
  - Double-braid cover by 50%
  - 12-strand braid by 25%
  - 8-strand plait by 25%
  - 3-strand by 10%
- ☐ Adjacent cut or pulled strands:
  - Class-I double-braid: 3 or more strands
  - 12-strand braid: 2 or more
  - 8-strand plait: 1 or more
  - 3-strand: 1 or more
- ☐ Diameter inconsistency
  - localised diameter reduction
  - flat areas
  - lumps and bumps in rope
- ☐ Glossy, glazed or melted fibres
- ☐ Inconsistent texture
- ☐ Areas of discolouration due to chemical contamination

If any of the above are found, either cut out the damaged section or cut and retire the rope.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Splices in rope

Splicing in rope is the forming of a semi-permanent joint between two or more ropes, or two parts of the same rope. Splices can be used to form a stopper at the end of a line, to form a loop or an eye in a rope, or for joining two or more ropes together.

Many ropes used in arboriculture are spliced, usually by the manufacturer of the rope or by professional splicers working for equipment retailers. Some arborists learn how to perform splicing both for their own ropes and for their colleagues'.

Most splices when correctly formed are significantly stronger than the knotted strength of the rope. The use of a splice in working ropes will tend to concentrate wear at the working (spliced) end; splices in used ropes should be inspected carefully.

Inspecting splices

1: Determine if the correct splice has been used

A variety of different splicing procedures can be used to form rope splices. Common splice constructions for arboricultural ropes include:

- Sixteen strand Class I
- Double-braid Class I
- Double-braid Class II (core dependant)
- Hollow braid
- Hollow braid (Locking Brummel)
- 3-Strand splice
- Variations including whoopee slings, loopie slings, etc
- Lock-stitched or sewn splices (bar tacked, machine sewn)

If the rope was spliced by the manufacturer and has been tagged by them, the correct splice should have been used. In other ropes, a common mistake is to use the wrong type of splice. Ensure that the splice follows the manufacturer's published splice instructions.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

2: Check that the splicer was competent to perform the splice

Many rope manufacturers publish splicing instructions, and additional information (both accurate and inaccurate) is available online from a variety of sources.

It is a requirement in both Australia and New Zealand that workers are suitably competent for their work tasks, and that businesses take reasonable steps to ensure the safety of their workers. This means that businesses must take reasonable steps to ensure the competence of anyone conducting splices in life-support or rigging equipment for their workers.

At minimum, it is the consensus of industry that arborists wishing to conduct splicing should:

- Take reasonable steps to ensure that their splices are correctly constructed, possibly including:
    - Seeking formal training and certification from professional splicers or certified splicers.
    - Submitting each type of splice (note – not each rope) that they will construct to be tested; the full MBS of the rope should be retained.
    - Retaining break testing or certification information in order to demonstrate the quality of their splices.
- Mark each splice with the following information:
    - The date of construction
    - The name of the person who performed the splice
    - The type of splice used, or, the MBS of the system with the incorporated splice

Splices that do not have this information, or where the operator is unable to provide details of the splice or of the splicer who constructed it, should not be passed during documented inspection unless the inspector is suitably competent to determine that the correct splice has been used, and that the splice has been correctly performed.

© Arboriculture Australia Ltd 2018

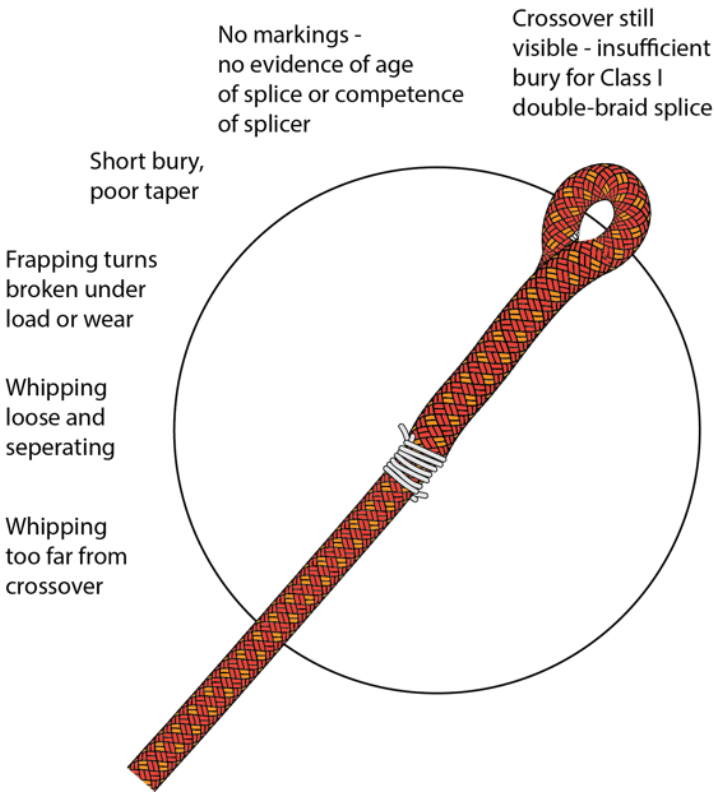
ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

3: Inspect splice

Competent inspection of splices will not be possible unless the inspector has a working knowledge of the different types of splices, and of how correct splices should look and feel in different rope types.

It remains the responsibility of the owner of the rope to present information to demonstrate to the inspector that the correct splice has been used and that the splicer was competent to perform the task.

Without this information, it is recommended that inspectors do not pass unmarked after-market splices unless they are competent to determine if the correct splice has been used and if it has been correctly performed.



© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope use

4: Use rope correctly and observe WLLs

Using rope incorrectly and applying excessive force will result in a shortened service life and unpredictable rope strengths. It is possible to push a rope 'to the limit' and get away with it, only for the rope to subsequently break on a much smaller load. Ropes that have been used in this manner may have damage concentrated in particular areas, inconsistent elongation and varying breaking strengths across their length.

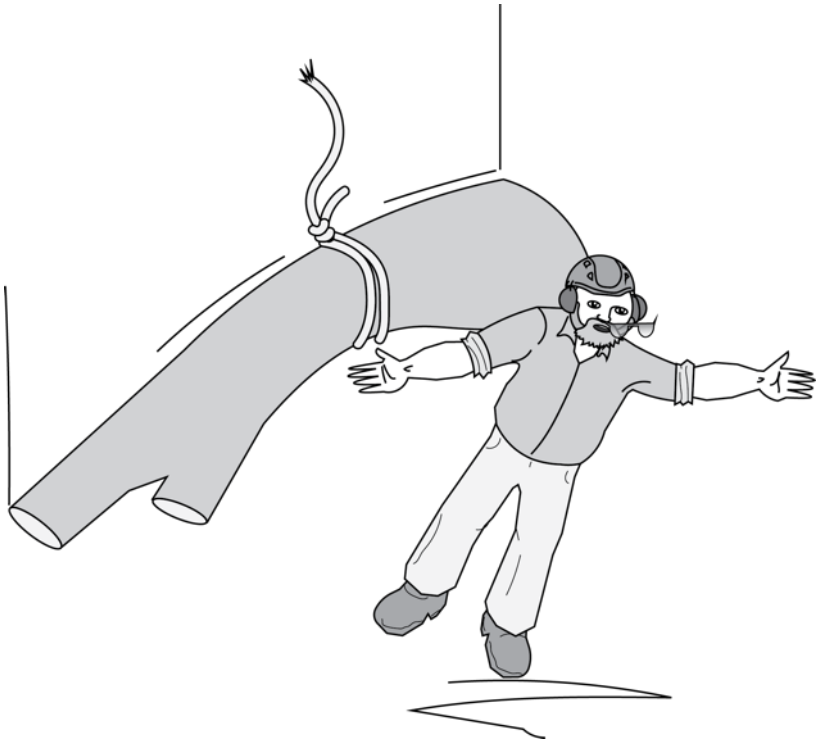
Poor rope use includes:

- applying loads above the WLL, particularly where loads include dynamic rigging operations and shock loading
- using ropes with small diameter-pulley sheaves, attached to karabiners or to other hardware with tight rope bend ratios
- loading ropes across inappropriate or poorly chosen knots
- poor care of ropes, including running ropes across abrasive surfaces such as tree bark, allowing heat build-up in ropes due to inappropriate use of devices, and poor site care of ropes such as dropping them in the dirt and walking over them
- impact damage to ropes, including during rigging operations or by dropping wood pieces on to ropes which have been left on the ground
- poor transport and storage of ropes, including packing ropes away wet or dirty, transporting ropes in contact with saws, sharp edges or abrasives, exposing ropes to fuel, oil or chemical contamination, or storing ropes in direct sunlight.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Not caring for your ropes is the same as not caring for your workmates – it's not only your life that is on the line!



© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Rope storage and transportation

5: Clean, store and transport rope carefully and correctly

- Clean rope after use wherever possible. For many rope types, sand and other particles that have become embedded in the rope during work will gradually abrade the rope wherever they rub.
- Clean ropes according to the manufacturer's recommendations for the material and construction. For many arborist ropes, washing with a diluted fabric softener has been found to help to maintain flexibility, keep fibres supple and reduce loss of rope strength over time. Washing nylon ropes may cause them to 'tighten' as nylon is hydroscopic.
- Store ropes appropriately for their construction. Ropes have memory – coiling many double-braid ropes will put a twist into the rope with each coil. If the rope is subsequently loaded before this twist is removed, the 'inner part' of the twist will be covering less distance than the outer part, and the load will not be shared evenly across the rope.
- Normally, coil twisted ropes and either wind braided ropes onto a drum (without being twisted) or flake them into a bag, however this is not critical.
- Transport ropes carefully, so that they will not be abraded, damaged, cut or exposed to fuel, oil or chemical contamination.
- Store ropes as clean and dry out of direct sunlight.

Look after your ropes and your ropes will look after you.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Appendix A: Rope inspection checklist

ROPE DATA, USAGE AND INSPECTION INFORMATION

Manufacturer:		Rope type:		Date of purchase:	
Construction:		Materials:		Recommended service life:	
Elasticity:	% @ Kg	M.B.S.:	Diameter:	Retire before:	
Elasticity:	% @ failure	W.L.L.:	Length:	Splice:	yes / no

OBTAIN AND ATTACH ROPE DATA SHEET IF AVAILABLE

At each inspection:

- Ensure that ropes are fit for intended purpose in original condition
- Check rope construction above and apply that knowledge when inspecting ropes for damage (see below)
- Inspect full length of rope for damage such as glazed areas (heat damage), inconsistent rope diameter (internal damage), discoloration (chemical contamination), and stiffness (exposure to chemicals or sap).
- Look particularly at areas where rope wear is likely to be concentrated, e.g. at the splice and near the working end
- Check for cuts, puffs (pulled strands), and areas of excessive fraying
- Ensure that all rope ends are secured, and will not unravel. Consider melting, glueing, whipping or taping, depending on rope type.
- Inspect splices for correct selection and construction - determine whether splices are suitable for purpose
- Record on rope inspection checklist to right

Inspection failure conditions:

Record failure and cut or retire if any of the following are found:

- Original rope bulk reduced by abrasion:
  - ☒ Double-braid cover by 30%
  - ☒ Twelve-strand braid by 25%
  - ☒ Eight-strand plait by 25%
  - ☒ Three-strand by 10%
- Adjacent cut or pulled strands:
  - ☒ Class I Double-braid: 3 or more
  - ☒ Twelve-strand braid: 2 or more
  - ☒ Eight-strand plait: 1 or more
  - ☒ Three-strand: 1 or more
- Diameter inconsistency:
  - ☒ Localized diameter reduction
  - ☒ Flat areas
  - ☒ Lumps and bumps in rope
- Glossy, glazed or melted fibres
  - ☒ Localized diameter reduction
- Inconsistent texture
  - ☒ Localized or extended areas of stiffness
- Discolouration
  - ☒ Localized or extended areas of chemical contamination

If any failure condition is met, record result with a cross below and cut or retire rope

DATE	INITIALS	✓ or ✗

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Glossary

8-strand plait	a rope construction consisting of 8 plaited strands and no core
3-strand rope	a rope construction consisting of three strands twisted together in a spiral pattern
12-strand rope	a rope construction consisting of 12 braided strands and no core
16-strand rope	a braided rope construction with a strength-carrying cover and a filler core
abrasion resistance (of rope)	the endurance of a particular cordage material or construction when subjected to wear
acceleration	the rate of change of speed of an object
anchor	in rigging, the point where the rigging system is tied off or where friction is controlled
anchor hitch	a knot commonly used to attach a line to a piece of hardware
axis or axes (of loading)	a direction in which a component can be loaded
balancer	rigging sling/s, usually with at least one spliced eye and a prusik to position the load line, used to rig a limb in a balanced configuration (see spider-leg balance)
becket	a secondary attachment point on a pulley
beer knot	a knot commonly used to join two ends of tubular webbing
bend	a knot used to join two lengths of rope or two ends of the same rope
bend radius	the radius of an object around which a line passes
bend ratio	the ratio of the diameter of a branch, sheave or other device to the diameter of the rope that is wrapped on it
bight	a curve or arc in rope
binding	a knot that is difficult to untie or move after loading
bitter end	another term for the ‘working end’

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

block	a pulley used in rigging, designed for dynamic loading
bowline	a looped knot used to attach items to a rope
bowline on a bight	a knot used to form two loops in the standing part of a rope
braided rope	rope construction in which the strands or yarns are woven together in a diagonal pattern
breaking strength	the force at which a piece of equipment or rope fails under a static load
butterfly knot	a knot that can be used to form a loop in the standing part of a line
capsizing	where a knot collapses or deforms into a different structure, usually the result of incorrect tying or misuse
chirality	the 'handedness' of a knot
clove hitch	a knot used to secure an object to a rope
collapse (of a knot)	where the knot deforms or disappears, usually after an object that the knot was formed around has been removed
configuration	the manner in which a component is connected to other parts of the rigging system or the manner in which it is used or loaded
construction (of rope)	the pattern in which fibres have been assembled to form the rope
cow hitch	a knot commonly used to attach hardware to a tree, generally backed up with a half hitch
creep	the slow loosening or reduction in tail length of a knot caused by rope stretch under load or the repeated loading and unloading of the knot; knots that creep should be tied off or backed up with a stopper knot
cycles to failure	the number of times a rope or other piece of equipment can be used with a given load before it fails
dead-eye sling	a rope sling with a single eye spliced in one end
design factor	the factor by which the rated or minimum breaking strength of the rope is divided in determining its WLL
double braid	a rope construction that consists of a braided rope within a braided rope

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

double fisherman's bend	a knot commonly used to join two ropes or two ends of the same rope, as when forming a prusik loop
dressing	the process of arranging a knot so that all parts of the knot sit correctly and the knot is correctly formed
dynamic loading	forces created by a moving load, the force of which, changes with time and motion
dynamic rope	a climbing rope designed to have high elongation in a fall, which acts to absorb the energy of the fall; almost never used in arboriculture
Dyneema	a synthetic fibre providing high abrasion resistance, very low elongation, highest strength to weight ratio of any fibre, excellent flex fatigue resistance but a low resistance to heat
elastic energy	kinetic energy, which is temporarily stored in a body or a system and conserved as elastic potential energy
elasticity, elongation, or **elastic elongation**	the proportion of its length that a part of cordage will extend under a given load
elbow	any two nearby crossings of a rope; an elbow is created when an additional twist is made in a loop
end line loop	a loop created in the end of a rope by forming any of numerous knots
energy	the potential to do work
eye	the fixed loop formed by tying a knot
eye splice	termination in a rope forming an eye and made by splicing the end of the rope back into itself
eye-to-eye sling	a length of rope spliced with an eye at each end
fall	a part of the rigging line from the rigging point to the anchor point
fibre	smallest element of a rope
fixed loop	webbing or rope sling that consists of a complete, closed loop
fixed rope anchor point	the point where a rope is tied or secured to a tree part or other anchor

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

fixed-eye sling (short)	a length of rope with an eye spliced in one end
fixed-length balancer	a sling, used in balancing limbs for removal that is not adjustable in length
flaking	to pack a rope into a bag or to lay a rope out on a surface ready for use
flexibility	how easy it is to tie knots in a particular rope and how well those knots are retained
force	the action of one object on another
French prusik	a type of friction hitch used in climbing and rigging
friction	a specific type of force that resists the relative motion between two objects in contact; the direction is always opposite the motion
friction device	a device used to take wraps in a load line; provides friction for controlled lowering
friction hitch	a way of wrapping one rope around another so the position can be adjusted
girth hitch	a simple knot used to attach a line, spliced eye or endless loop to an object
grip	the degree to which a rope will run or bind when used in a rope-on-rope configuration in conjunction with other cordage
half-hitch	a simple knot used to temporarily secure a line to an object; also used as a backup in combination with other knots
hand	the flexibility of a particular rope, how easy it is to tie knots and how well those knots are retained
heat resistance	the ability of a particular rope material to withstand heat without damage or strength reduction
hitch	a type of knot that attaches a rope to some object or other rope; if the object is removed, the hitch may collapse
hollow braid	a braided rope construction having an empty centre
karabiner	oblong metal ring, used in climbing and static rigging that is opened and closed by means of a spring-loaded gate
Kernmantle	rope manufactured with a strength-carrying core to have a core and braided sheath

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Kevlar	a synthetic fibre primarily used in ropes for high heat resistance, low elasticity and high strength
knotted strength (of rope or slings)	the reduced strength of a particular cordage type when a knot is incorporated into the loaded section
lead	the part of the rigging line from the rigging point to the load
lifting	a rigging technique in which the tip of a branch is raised up before lowering in order to avoid obstacles below lifting cut; a variation of the hinge-cut technique used to cut limbs that are being lifted
loop	a bight that crosses itself or a bight made fast with a knot
loop knot	any of numerous knots that can be used to form a loop in a line
loopie	a specific type of sling made up as an adjustable loop
marline hitch	a simple hitch used in lashing; in rigging, a secondary knot used in combination with a primary attachment knot to tie-off sections for lowering
marling	the act of forming a marline hitch in series along an object
materials (of rope or slings)	the textiles or cordage substances that have been used to make the rope
midline loop	a loop made fast with a knot formed in the standing part of a line
Minimum breaking strength	also known as minimum break strain and usually expressed in Kilonewtons (kN), this figure is the load above which an item of lifting equipment can be expected to fail when new and when used in the correct configuration; this number will drop rapidly i.e. the equipment will break much sooner than expected such as when using old, worn, damaged or mis-configured equipment
natural-crotch rigging	rigging methods that utilise natural crotches for the rigging points
nylon	a material used in rope construction, with good strength, high elasticity (48%), and good abrasion, heat and UV resistance
polyester	a material used in rope construction, with good strength, moderate elasticity (38%), and excellent abrasion, heat and UV resistance
polypropylene	a material used in rope construction, with moderate strength, moderate elasticity (38%), and poor heat and UV resistance

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

profile (of rope)	the smoothness or roughness of the circumference of the perpendicular cross-section of the rope
prusik	see prusik hitch
prusik hitch	a type of multi-wrapped friction hitch used in climbing and rigging; used to attach the prusik loop to the climbing line when footlocking
prusik loop	a loop of rope used to form a prusik hitch for climbing or rigging
prusik-minding	a specific type of pulley configured with extended cheek plates to keep a prusik from jamming in the sheave
pulley	a device consisting of a rotating, grooved wheel between two side plates; used to change the direction of pull in a line
recommended rope diameters	for some hardware such as blocks, pulleys and bollards, the manufacturer may provide a recommended range of rope diameters; may be printed on the device (sometimes shown as ⌽ or ⌀) or can be found in the manual; exceeding the recommended rope diameter may result in abrasion of hardware, damage to rope or reduction in rope strength (see bend ratio)
rigging	a method for using ropes and hardware to remove large limbs or to take down trees
rigging point	the place in the tree (natural or false crotch) that the load line passes through to control limb removal in rigging operations
rope bag	a bag used to store climbing and rigging lines
rope sling	a section of rope, usually with at least one eye splice, used to secure equipment or tree sections in rigging operations
round turn	two turns of a line around an object
running bowline	a knot often used to tie-off limbs for removal
running end	the end of a rope not in use
safety factor	the factor by which the rated or minimum breaking strength of the rope is divided in determining its WLL
semi-static (of rope)	has up to approximately 5% elastic elongation at the WLL

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

service life	the maximum number of years recommended by the manufacturer for that product to be used before retirement, assuming that the product is used and cared for correctly, not damaged and subjected to regular inspection
setting	the process of tightening a knot by applying load
sheave	the inner fitting within a block over which the rope runs
sheet bend	a knot used to attach two lines; the lines can be of unequal diameter
sling	a device used in rigging to secure equipment or pieces being rigged
slip knot	a slipped overhand knot
slipped (in knots)	having a bight of rope passed through the final tuck in a knot to provide for quick release
slippery bend	a knot used to attach two lines; can be released quickly by pulling on the final tucked bight
solid braid	a rope construction consisting of a single pattern of load-bearing fibres, with or without a filler core in the middle of the rope
specifications (of rope)	the particular manufacturer-defined or inherent properties of a particular rope, such as rope diameter, length, WLL and other qualities
Spectra	a very strong synthetic fibre with excellent abrasion resistance but low resistance to heat; very low elasticity (ultra-static)
spider balancer or spider-leg balancer	a system utilising multiple slings to lower a large limb with a wide spread without allowing either the butt or any of the tips to swing or drop down when the limb is cut
splice	a method of joining two ropes or of forming an eye in a rope by re-weaving the rope strands or by re-burying rope parts within itself
spliced eye	see eye splice
spliced strength (Of rope or slings)	strength of the rope when the splice is incorporated into the loaded system
spliced-eye sling	a length of rope with an eye spliced in the end
standing part	the inactive part of a rope, as opposed to the working end

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

static removable (retrievable) false crotch	false crotch, usually an arborist block, that can be set in a tree and removed from the ground
static rope	static or ultra-static rope is designed to have minimal elongation
stopper knot	a knot tied to prevent the end of the rope slipping through an adjustor or to prevent the end of a rope slipping through a knot
strand	the largest component of a rope; yarns are twisted to form strands, and strands are twisted (usually in the opposite direction) or braided to form rope
TDSF	acronym for tie, dress, set and finish
tagline	a rope used to control the swing of a limb being removed; a rope used to control the direction or fall of a tree or limb being removed
technique	a means of accomplishing a task
Technora	a synthetic fibre primarily used in ropes because of its high strength and low elasticity
tensile strength	force at which a new piece of equipment or rope fails under a static load in testing
tie-off	a method of securing the tail of a knot so it will not creep or slip
timber hitch	a knot consisting of a series of wraps on a rope; used to secure the rope to a limb or tree
turn	one wrap of a rope around an object
twisted	a rope construction made by twisting bundles of fibres to form strands, which are then twisted to form rope
ultra-static (of rope)	has up to approximately 0.5% elastic elongation at the WLL
Ultraviolet resistance or **Ultraviolet stability**	the ability of a particular material to withstand the damage and loss of strength caused by exposure to sunlight
Valdôtain tresse (Vt)	a variation of the French prusik used as a friction hitch in climbing and rigging
water knot	a variation of the overhand knot used in joining ends of webbing slings

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

webbing sling	length of sewn webbing, often formed into a loop, used as an attachment in rigging
weight (of rope)	how heavy the rope is per metre of length
whoopie sling	a sling with one fixed eye and one adjustable eye, made from hollow-braid rope
working end	the end of a rope in use
working load	the load that is applied to a rope in normal service
working load limit	the maximum recommended load a piece of equipment should experience when correctly configured during regular operations; WLL can be calculated by tensile strength divided by design factor; maximum load that should not be exceeded in a rope or rope assembly when performing its normal working function
wrap	passing a rope around an object (usually a friction device or some part of a tree) to create friction to control a heavy load in a rigging operation
yarn	the component of a rope formed from twisted fibres; yarns are then twisted into strands
Zeppelin bend	knot used to join two ropes

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

References

- Ashley, CW 1993, *The Ashley Book of Knots*, Faber & Faber, London, United Kingdom.
- Brudi & Partner TreeConsult and Treevolution Arboricultural Services, Chris Cowell (Treepartner), and Paul Howard (ArBO) 2008, *Evaluation of Current Rigging and Dismantling Practices used in Arboriculture, Health and Safety Executive*, London, United Kingdom.
- International Society of Arboriculture, 2018, *Dictionary*, Champaign, Illinois, United States.
- Jepson, J 2007, *The Tree Climber's Companion: A Reference And Training Manual For Professional Tree Climbers*, Beaver Tree Publishing, Longville, Minnesota, United States.
- Lingens, D 2006, *Tree Climbers Knotbook*, Schlauverlag, Stockelsdorf, Germany.
- Philpott, L 2006, *Pocket Guide to Knots*, IMM Lifestyle Books, New Holland, London, United Kingdom.
- SampsonRope, 2005, *Professional Arborist Ropes*, Samson Rope Technologies <www.samsonrope.com>.
- Yale Cordage <www.yalecordage.com>.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Minimum Industry Standards

This document is one in a series of Minimum Industry Standards ("**MIS**") produced by Arboriculture Australia Ltd in partnership with the New Zealand Arboricultural Association and the wider arboriculture community to ensure that all people working, assessing and providing advice in relation to trees (excluding commercial forestry) have access to industry peer-reviewed documents explaining the core standards of skills and equipment with which competent practitioners should be familiar.

Where a MIS exists for a particular task, it is deemed by industry experts to:

- Provide an overview of the task, as it is practiced in industry.
- Define an industry consensus regarding the current appropriate applied-practice ways of conducting that task.
- Specify the minimum skill and knowledge requirements for performing particular tasks in the workplace.

At times, the complexity of a task may surpass the level of skill described in a MIS. It is the practitioner's responsibility to clearly understand and interpret the level of skill described in the MIS and whether that level is adequate for the task before them. In many cases a person will need to refer to several MIS documents to complete one task.

The prime purpose of the MIS is to provide minimum standards for the safety of tree workers, while still encouraging and fostering innovative practices.

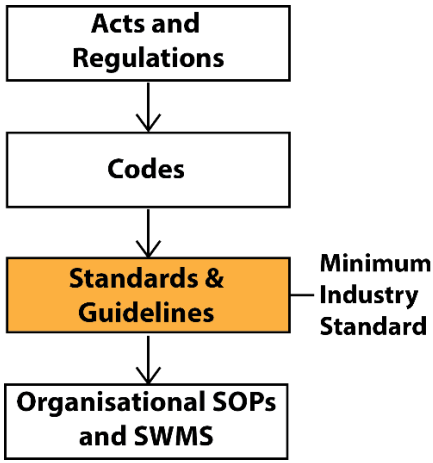
Equipment, tests, inspection or practices other than those in this document may be perfectly satisfactory. Organisations are at liberty to provide different equipment, to specify different tests, or to inspect equipment in a manner or at intervals assessed as appropriate to particular circumstances, provided that these alternatives are based on sound design or reasoning and that the outcome of worker safety is not prejudiced.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Both Arboriculture Australia Ltd and the New Zealand Arboricultural Association encourage any worker in any industry to conduct annual continued education and training to grow their competency in specific tasks and ensure they have appropriate training in the task being conducted prior to commencing any work.

The following diagram outlines the framework into which this MIS fits:



This MIS does not substitute for, or override, any legislation or regulation enacted by jurisdictional regulators or safety rules implemented by organisations. As depicted above, it is merely a guiding tool within the system.

Arboriculture Australia Ltd and the New Zealand Arboricultural Association will monitor the use and impact of these MIS and, consequently, may review and amend as the industry continues to evolve.

It is not the responsibility of Arboriculture Australia Ltd or of the New Zealand Arboricultural Association to notify users of these documents when reviews and reprints occur.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Using the MISs in training and assessment

This document provides information that can be used to assist students/learners in gaining knowledge and understanding industry terminology and norms. Learning and practising skill components must be conducted under the supervision of a competent person or trainer. Do not attempt to practice any of the techniques described in this document without the supervision of a competent practitioner.

In Australia

A key outcome for the production of national MIS documents is their use to support training aligned to the units of competency from the Australian AHC Agriculture, Horticulture, Conservation and Land Management Training Package, in particular the arboricultural industry sector-specific units of competency.

The MIS for each work task defines an industry consensus of the benchmark of competence in a work task. Therefore, it is an assessment requirement for each unit of competency that the performance criteria, performance evidence and knowledge evidence demonstrated by the candidate is **at least** to the level described in the MIS for that work task.

Where units of competency are not specific in their description of the industry techniques or benchmark of ability expected of holders of that unit, RTOs should use the relevant MIS document as a supplementary guide for industry expectations when conducting training or designing assessment instruments.

This does not mean that techniques or equipment not described in the relevant MIS should not be taught or assessed. There are many ways to appropriately complete each task and some methods and equipment may be more advanced than those in this document.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

In New Zealand

A key outcome for the production of national MIS documents is their use to support training and education towards the New Zealand Certificates in Horticulture Services (Arboriculture) and Arboriculture. These Certificates (Levels 3 to 5) are designed to provide the arboriculture industry with individuals who have the technical skills and knowledge to safely undertake and manage arboriculture operations to maximise effectiveness.

The MIS for each work task defines an industry consensus of the benchmark of competence in a work task. The level at which the work task is assessed will reflect the New Zealand Qualification Authority (NZQA) Level, the Strategic Purpose of the qualification and the corresponding Educational and Employment Pathway. Depending on the relevant Graduate Profile, work tasks described in the MIS may address the content of more than one qualification and may progress more than one Education Pathway.

This does not mean that techniques or equipment not described in the relevant MIS should not be taught or assessed. There are many ways to appropriately complete each task and some methods and equipment may be more advanced than those in this document.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Disclaimer for MISs and all associated documents

This document refers to various standards, guidelines, calculations, legal requirements, technical details and other information. It is important that readers and parties who implement this MIS are aware of the duties and recommendations contained in these other sources.

Over time, changes in Australian and New Zealand Standards, industry standards and legislative requirements, as well as technological advances and other factors relevant to the information contained herein may affect the accuracy of the information contained in this document. Accordingly, caution should be exercised in relation to the use of the information in this document.

Arboriculture Australia Ltd and the New Zealand Arboricultural Association will regularly update the MISs as deemed necessary. It is the responsibility of the user to ensure the version they are using is current. It is not the responsibility of Arboriculture Australia Ltd or of the New Zealand Arboricultural Association to notify users of these documents when reviews and reprints occur. Please go to the Arboriculture Australia Ltd website at *trees.org.au* or to the New Zealand Arboricultural Association website at *nzarb.org.nz* to confirm that you are using the current version.

The information in this document has been reviewed and validated by state and national industry representatives and deemed to be an accurate description of appropriate applied-practice skills and techniques. Arboriculture Australia Ltd and the New Zealand Arboricultural Association accept no responsibility or liability for the accuracy of any information contained herein, or the consequences of any person relying on such information. All arboriculture work is undertaken at your own risk.

© Arboriculture Australia Ltd 2018

ISSUED UNDER LICENSE TO
ACTIVE TREE SERVICES
License Number: 19871
THIS DOCUMENT IS VALID UNTIL:
30/06/2023

Industry stewardship program

The development of the Minimum Industry Standards has been made possible by generous support from the following businesses who provided financial seed funding to the project to improve and increase education and safety in the arboriculture and vegetation management industries.

Project partners

Project sponsors

Project supporters

© Arboriculture Australia Ltd 2018

Arboriculture Australia™

This book is one in a series of Minimum Industry Standards developed by Arboriculture Australia Ltd. and the New Zealand Arboricultural Association in partnership with the national arboriculture and vegetation management communities in both countries. These industry peer-reviewed standards explain the skills and equipment with which competent practitioners should be familiar.

NZARB™
New Zealand Arboricultural Association Inc.

MIS302 ARBORIST ROPES covers the fundamentals of rope selection, qualities of ropes and rope use: it is intended to provide a solid foundation of rope knowledge on which practitioners can build.

ISBN 978-0-6486866-6-8

MIS302
Arborist Ropes
2nd edition
RRP:
AUS: $27.50
NZ: $29.00